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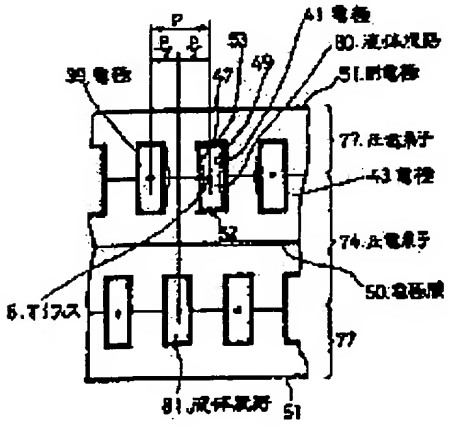
(54) INK JET HEAD



(57)Abstract:
PURPOSE: To obtain a high side wall strength and perform a high-density printing by a method wherein N liquid flow paths partitioned by side walls made of a piezoelectric material polarized in one direction are privided, and the trains of liquid flow paths are arranged so as to be shifted by an amount of P/N (P is a pitch of liquid flow paths).
CONSTITUTION: A piezoelectric element 74 is electrically polarized in opposite directions across an electrode film 50. Piezoelectric elements 77 are formed on and under the piezoelectric element 74. Upper and lower liquid flow paths 80, 81 are provided between the both piezoelectric elements. Electrodes 39, 41, 43 are respectively provided around the upper liquid flow paths 80. Sub- electrodes 51 are provided on the back surfaces of the piezoelectric elements 77. By applying a drive voltage to the electrode 41. with the electrodes 39, 43 previously grounded, the both side walls of the liquid flow path 80 are deformed as shown by dotted lines 47, 49, 52, 53, and a liquid drop is jetted out of an orifice. In the lower liquid flow path 81, a liquid drop is also similarly jetted out. Since the upper and lower liquid flow paths 80, 81 are respectively arranged at a pitch P with a shift of P/2 from each other, printing can be performed with a dot density

88 LIQUID FLOW PATH
89 LIQUID FLOW PATH

FIG. 1

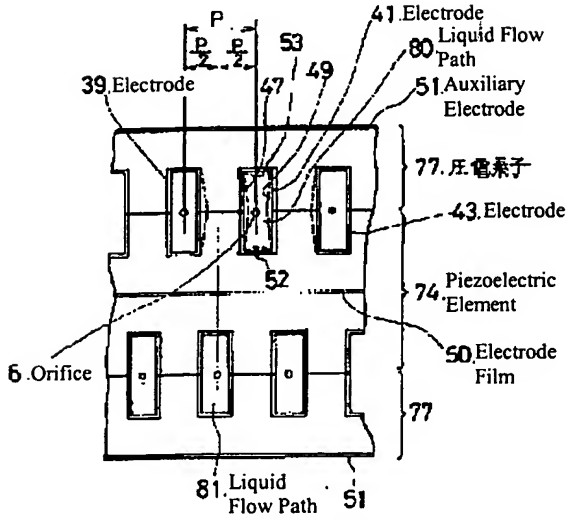


FIG. 2

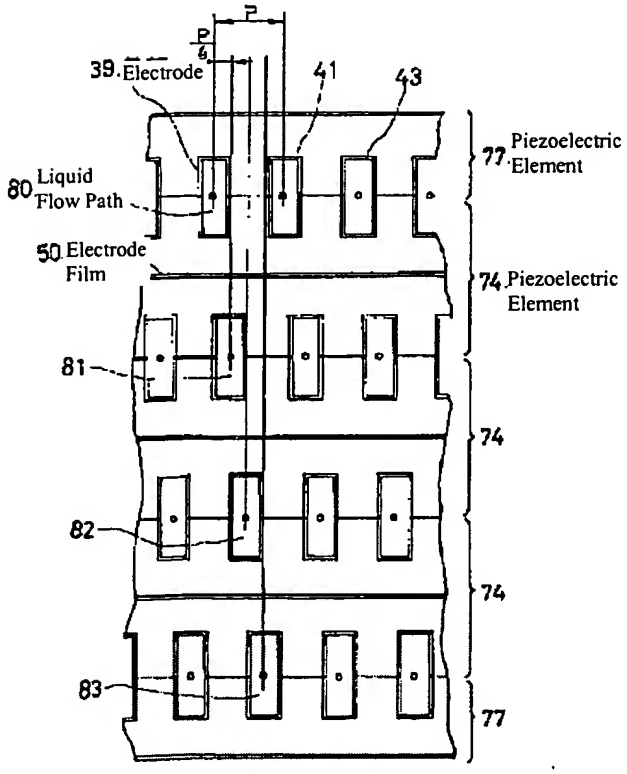


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FIG. 3

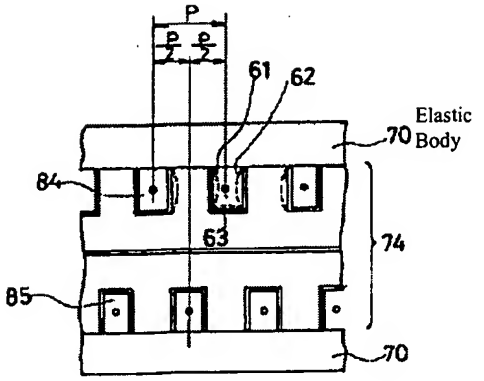


FIG. 4

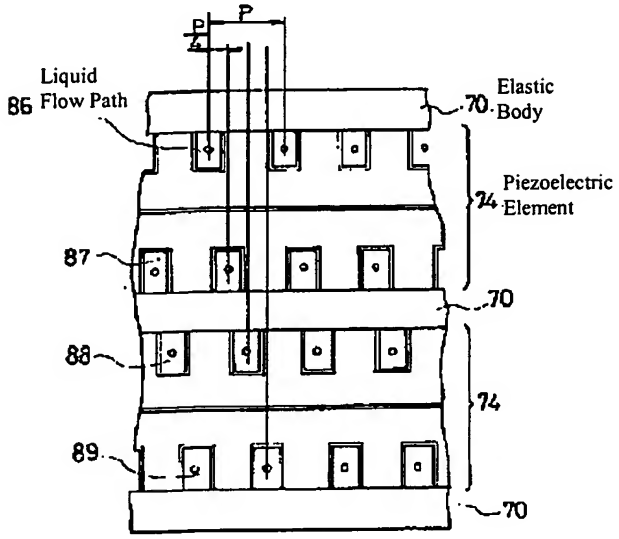


FIG. 5

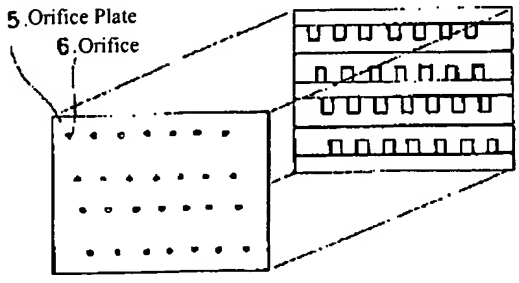


FIG. 6

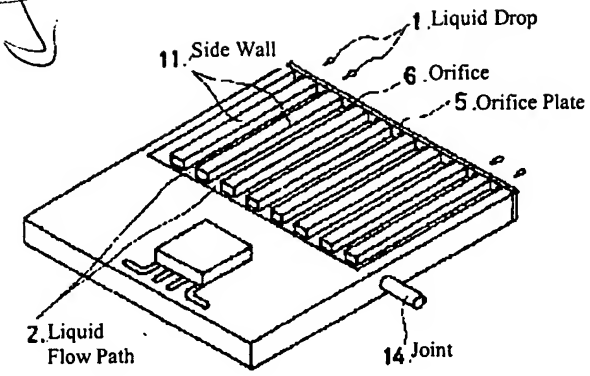
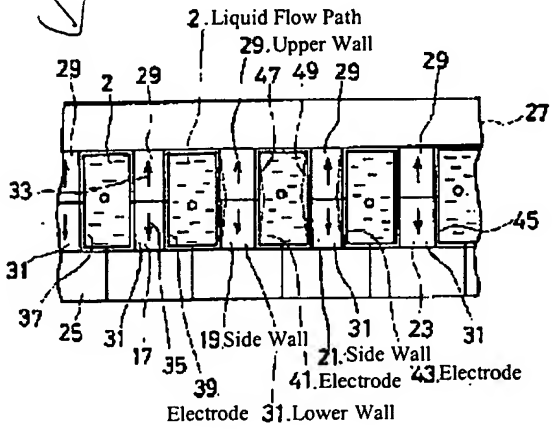
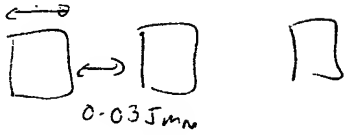


FIG. 7



At 360 dpi
0.035 mm



but this doesn't work -
- side walls too weak
- flow not good

Proposed 0.07 mm

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(54) (Title of the Invention) INK JET HEAD

(57) (Abstract)

(Object) It is an object of the present invention to provide a shear-mode ink jet head in which orifices for ejecting a liquid present in liquid flow paths are arranged with a high density and high accuracy.

(Structure) There are N rows of liquid flow paths arranged with a pitch P, and liquid flow paths in each row are arranged with a shift of P/N with respect to the liquid flow paths in another row. Furthermore, the orifices for ejecting the liquid drops are formed in one orifice plate.

(Effect) Because a stacked configuration of liquid flow paths is used, the integration density of liquid flow paths is increased. Furthermore, because the orifices of liquid flow paths of multiple rows are gathered in one orifice plate, a head with a high printing accuracy can be obtained.

(Patent Claims)

(Claim 1) An ink jet head characterized in that there are N rows of liquid flow paths partitioned by side walls composed of a piezoelectric material polarized in a fixed direction, those liquid flow paths being arranged with a pitch P in one row, the liquid flow paths in each row are arranged with a shift of P/N between the rows, an electrode is formed on the inner surface of each liquid flow path, each liquid flow path is filled with a liquid, the liquid flow paths are linked together by liquid chambers provided in each row, a drive voltage is applied to said electrodes to induce the deformation of said side walls, and recording is conducted by ejecting liquid drops from orifices provided in each said liquid flow path.

(Claim 2) The ink jet head according to claim 1, characterized in that all the orifices are provided in one orifice plate.

(Claim 3) The ink jet head according to claim 1, characterized in that electrode films are provided correspondingly to the inner surface electrodes perpendicular to the side walls of said liquid flow paths, the drive voltage is also applied between the said inner surface electrodes and electrode films, the deformation of the side walls and the deformation of the inner surfaces perpendicular to the side walls are induced simultaneously, and liquid drops are ejected from the orifices.

(Detailed Description of the Invention)

(0001)
(Technical Field of Application) The present invention relates to an ink jet printer, more specifically to an ink jet head in which liquid drops are ejected by using a shear-mode deformation.

(0002)
(Prior Art Technology) Non-impact recording methods have recently attracted much attention because they reduce noise during printing to a negligibly low level and are readily suitable for color recording. Among these, new high-performance devices of ink jet printers based on a liquid jet recording method that allows for high-speed recording on normal paper have appeared, and among them the drop-on-demand ink jet printers have been recently used in large numbers as output devices of personal computers because they eject only the necessary liquid drops, do not require waste liquid recovery mechanisms, and have a simple structure and a low cost.

(0003) However, in the case of ink jet printers of a thermomechanical conversion system (Japanese Published Unexamined Patent Application S54-59936), cogation is induced on the heater surface by the components of the liquid and this cogation degrades the efficiency of the ink jet head with time and can lead to a fracture. For this reason, it becomes necessary to limit the number of components contained in the liquid. On the other hand, in the printers of an electromechanical conversion type (Japanese Published Unexamined Patent Application S47-2006), the printer structure requires a spacing of 0.3 mm between the orifices, which is larger by a factor of about 5 than that in the thermomechanical system. As a result, it is difficult to

piezo elements usually have nozzles spaced 0.3 mm

construct an ink jet printer with good utility in which a large number of orifices are provided with a high density. One of the methods for resolving those problems comprises using an ink jet head of a system in which an electrostriction effect caused by a shear-type mode is used to deform the side walls of the liquid flow paths provided in a piezoelectric element and thereby eject the liquid drops.

(0004) A perspective view of the ink jet head based on this technology (this ink jet head was disclosed in Japanese Published Unexamined Patent Application S63-252750) is shown in FIG. 6, and a cross-sectional view of the head is shown in FIG. 7. In this head, as shown in FIG. 6, multiple liquid flow paths 2 partitioned by side walls 11 are provided in the vicinity of an orifice plate 5 provided with orifices 6 for ejecting liquid drops 1. The liquid flow paths 2 are filled with the liquid, and the liquid is supplied from a joint 14. Referring to FIG. 7, the side walls denoted by reference numerals 15, 17, 19, 21, and 23 are formed from an upper wall 29 and a lower wall 31 polarized in the mutually opposite directions as shown by arrows 33, 35 in the figure. Those side walls are sandwiched between the bottom plate 25 and top plate 27 and constitute the liquid flow paths 2. Electrodes 37, 39, 41, 43, and 45 cover the entire inner walls of the respective liquid flow paths 2. Here, for example, if a voltage is applied to the electrode 41 of the liquid flow path 2 between the side walls 19, 21 and the electrodes 39, 43 on both sides are grounded, then an electric field is applied to the side walls 19 and 21. Because the upper wall 29 and lower wall 31 of the side walls are polarized in the opposite direction, the upper wall 29 and lower wall 31 are deformed in a shear-type mode toward the liquid flow path located therebetween, as shown by the dotted lines 47, 49. As a result, a pressure is applied to the liquid located in the liquid flow path 2 present between the side walls 19, 21, an acoustic pressure wave propagates along the length of the flow path, and liquid drops 1 are ejected from the orifices 6.

(0005)
(Problems Addressed by the Invention) When a printing density of 360 dpi is realized by using an ink jet head with a shear-type mode, the flow path width and the side wall thickness are 0.035 mm each, the width of the flow channel becomes too small and the resistance of the flow channel becomes too high. Moreover, the head is also impractical from the standpoint of side wall strength. It is an object of the present invention to resolve those problems associated with high-density printing and to provide an ink jet head providing for a high resolution.

(0006)
(Means to Resolve the Problems) In order to resolve the above-described problems, the present invention provides an ink jet head characterized in that there are N rows of liquid flow paths partitioned by side walls composed of a piezoelectric material polarized in a fixed direction, those liquid flow paths being arranged with a pitch P in one row, the liquid flow paths in each row are arranged with a shift of P/N between the rows, an electrode is formed on the inner surface of each liquid flow path, each liquid flow path is filled with a liquid, the liquid flow paths are linked together by liquid chambers provided in each row, a drive voltage is applied to the electrodes to induce the deformation of the side walls, and recording is conducted by ejecting liquid drops from orifices provided in each liquid flow path. The ink jet head in accordance with the present invention is also characterized in that all the orifices are provided in one orifice plate. Furthermore, it is also characterized in that the electrode films are provided correspondingly to the inner surface electrodes perpendicular to the side walls of the liquid flow paths, the drive

voltage is also applied between the inner surface electrodes and electrode films, the deformation of the side walls and the deformation of the inner surfaces perpendicular to the side walls are induced simultaneously, and liquid drops are ejected from the orifices.

(0007)
(Operation) The liquid drop ejection recording apparatus in accordance with the present invention has a multilayer structure in which liquid flow paths are arranged with a high density. Therefore, the width of liquid flow paths in each row and the width of side walls can be increased to 0.07 mm each, the resistance of liquid flow paths is decreased, and the ejection energy is reduced. Moreover, the structure is also improved in terms of the side wall strength because a sufficient side wall width can be obtained. Furthermore, because the liquid flow paths are integrated with a high density, all the orifices can be provided in one orifice plate and an ink jet head with a high printing accuracy can be produced by merely managing the positional accuracy of the orifices on the orifice plate, regardless of the lamination error of piezoelectric element modules. Moreover, because the direct-mode deformation of bottom walls of the liquid flow paths is used simultaneously with the shear-mode deformation of side walls as a means of energy deposition, the ink jet head with a high density and a high drive force can be obtained.

(0008)
(Embodiments) The embodiments of the present invention will be described hereinbelow in greater detail with reference to the appended drawings. FIG. 1 illustrates the first embodiment of the ink jet head in accordance with the present invention. A piezoelectric element 74 is electrically polarized in opposite directions while sandwiching an electrode film 50. Piezoelectric elements 77 are provided on and under the piezoelectric element 74, and upper liquid flow paths 80 and lower liquid flow paths 81 are formed. Electrodes 39, 41, 43 are provided around the upper liquid flow paths 80. Auxiliary electrodes 51 are provided on the back surfaces of the piezoelectric elements 77. By applying a drive voltage to the electrode 41, with the electrodes 39, 43 being grounded, both side walls of the liquid flow paths 80 are deformed as shown by the dotted lines 47, 49, 52, 53, and liquid drops are ejected from the orifices. Because the upper liquid flow paths 80 and lower liquid flow paths 81 are respectively arranged with a pitch P, and the upper and lower paths are shifted by P/2 with respect to each other, printing can be performed with a dot density twice as high as that of the conventional structure, even with the width of the side wall of the conventional structure. The liquid flow paths 80, 81 are disposed so as to be arranged in the printing column direction. When printing is conducted by using this ink jet head, the printing paper is scanned in the direction perpendicular to the liquid flow path row. Therefore, the drive has to be conducted so that, first, the upper liquid flow paths 80 are discharged and then the lower liquid flow paths 81 are discharged after the fixed interval required for the lower liquid flow paths 81 to reach the printing point. Furthermore, even with the identical liquid flow path rows, liquid drops cannot be ejected simultaneously from the adjacent liquid flow paths. Therefore, the driving is conducted with a time difference of several hundreds of microseconds required for the attenuation of vibrations of the liquid flow path after the initial liquid drop is discharged.

(0009) FIG. 2 illustrates the second embodiment of the ink jet head in accordance with the present invention. This embodiment represents an example relating to the case in which a total of three piezoelectric elements 74, which sandwich electrode films 50 in the middle of the plate

thickness, have both sides thereof electrically polarized in the opposite directions, comprise grooves for constituting a plurality of liquid flow paths 80, 81, 82, 83 on both surfaces thereof, and have electrodes 39, 41, 43 from an electrically conductive film provided on the inner surface of the grooves are joined so that the grooves match each other, and the piezoelectric elements 77 provided with grooves are joined on the outer sides, thereby comprising liquid flow paths 80, 81, 82, 83 and providing a means of energy deposition. Each of the four rows of the liquid flow paths 80, 81, 82, 83 has a pitch P and the rows are shifted by P/2 with respect to each other. Therefore, printing can be conducted with a dot density by a factor of four higher than that of the conventional structure.

(0010) FIG. 3 illustrates the third embodiment of the ink jet head in accordance with the present invention. In this embodiment, elastic bodies 70 are joined instead of the piezoelectric elements 77 shown in FIG. 1. The piezoelectric element 74 deforms as shown by the dotted lines 61, 62 by the shear-mode deformation, the bottom portion deforms as shown by a dot line 63 by the direct-mode deformation, thereby causing reduction of the cross-sectional area of the liquid flow path, applying pressure to the liquid located inside the liquid flow path 84, and pressing it out to the orifice and liquid chamber. In this case, too, the upper liquid flow paths 84 and lower liquid flow paths 85 are arranged with a pitch P, and the upper and lower rows are shifted by P/2. Therefore, printing can be conducted with a dot density twice as high as that of the conventional structure, even when the grooves are machined to the size providing for a sufficient strength of side walls 11 as in the conventional structure. In the present embodiment, the number of piezoelectric elements 74, 77 may be reduced by two and the configuration is more practical from the standpoint of product cost.

(0011) FIG. 4 illustrates the fourth embodiment of the ink jet head in accordance with the present invention. In the layered structure of the present embodiment, two heads of the third embodiment are stacked so that they share one elastic body 70. The liquid flow paths 86, 87, 88, 89 have a pitch shift of P/4. Therefore, in this case, too, printing can be conducted with a dot density four times that of the conventional structure. Furthermore, the number of piezoelectric elements 74, 77 in this embodiment is reduced by three with respect to that in the example shown in FIG. 2, thereby making the configuration more practical from the standpoint of product cost.

(0012) FIG. 5 illustrates the configuration of the orifice plate corresponding to the head of the fourth embodiment. A multiplicity of orifices 6 linked to the liquid flow paths are provided in one orifice plate 5. The orifices may be assembled in one orifice plate also in the heads shown in FIGS. 1 through 3. Thus, with the head configuration in accordance with the present invention, the arrangement density of liquid flow paths can be increased even if the number of liquid flow paths is increased. Therefore, all the orifices 6 constituting the ink jet head can be provided in one orifice plate 5. Furthermore, with such a configuration, the relative positions of the orifices may be such as to manage the machining accuracy of the orifice plate 5, and therefore, high-accuracy printing quality can be easily reached.

(0013)
(Effect of the Invention) As described hereinabove, in accordance with the present invention, the liquid flow paths have a multistage configuration. Therefore, the liquid flow paths can be arranged with a high density, while the width of the liquid flow paths and the width of the side

wall remain the same as in the conventional structure. In addition, the integration density of liquid flow paths can be further increased not only with the shear-mode deformation employed as a means of energy deposition, but also by providing electrode films correspondingly to the upper-level bottom and lower-level bottom of the liquid flow paths and providing ejection energy to the liquid by inducing the direct-mode deformation of the upper-level bottom and lower-level of the liquid flow paths. Furthermore, configuring multistage orifices on one orifice plate makes it possible to obtain an ink jet head for high-quality printing in which orifices are arranged with high accuracy.

(Brief Description of the Diagrams)

FIG. 1 is a cross-sectional view of the ink jet head of the first embodiment of the present invention;

FIG. 2 is a cross-sectional view of the ink jet head of the second embodiment of the present invention;

FIG. 3 is a cross-sectional view of the ink jet head of the third embodiment of the present invention;

FIG. 4 is a cross-sectional view of the ink jet head of the fourth embodiment of the present invention;

FIG. 5 illustrates the orifice plate in accordance with the present invention;

FIG. 6 illustrates the external appearance of the conventional ink jet head; and

FIG. 7 is a cross-sectional view of the conventional ink jet head.

(Keys)

1	LIQUID DROP
2	LIQUID FLOW PATH
5	ORIFICE PLATE
6	ORIFICE
11	SIDE WALL
39	ELECTRODE
41	ELECTRODE
43	ELECTRODE
50	ELECTRODE FILM
51	AUXILIARY ELECTRODE
70	ELASTIC BODY
74	PIEZOELECTRIC ELEMENT
77	PIEZOELECTRIC ELEMENT
80	LIQUID FLOW PATH
81	LIQUID FLOW PATH
82	LIQUID FLOW PATH
83	LIQUID FLOW PATH
84	LIQUID FLOW PATH
85	LIQUID FLOW PATH
86	LIQUID FLOW PATH
87	LIQUID FLOW PATH